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Do you understand what I want to tell you?

Early sensitivity in bilinguals' iconic gesture perception and production

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Research highlights

- Successful communication requires sensitivity for others' needs and intentions. Previous research indicates that bilingual children show heightened communicative sensitivity.
- The current results suggest that bilingual pre-schoolers produce more intelligible iconic gestures than their monolingual peers.
- Parents of bilingual children produced more iconic gestures than parents of monolingual children. Parental gesture frequency did not influence children's iconic gesture production.
- The findings expand previous research by showing that bilinguals' increased communicative sensitivity may help them to produce more intelligible non-verbal signals.

Abstract

Previous research has shown differences in monolingual and bilingual communication. We explored whether monolingual and bilingual pre-schoolers' ($N = 80$) differ in their ability to understand others' iconic gestures (gesture perception) and produce intelligible iconic gestures themselves (gesture production) and how these two abilities are related to differences in parental iconic gesture frequency. In a gesture perception task, the experimenter replaced the last word of every sentence with an iconic gesture. The child was then asked to choose one of four pictures that matched the gesture as well as the sentence. In a gesture production task, children were asked to indicate "with their hands" to a deaf puppet which objects to select. Finally, parental gesture frequency was measured while they answered three different questions. In iconic gesture perception, monolingual and bilingual children did not differ. In contrast, bilinguals produced more intelligible gestures than their monolingual peers. Finally, bilingual children's parents gestured more while they spoke than monolingual children's parents. We suggest that bilinguals heightened sensitivity to their interaction partner supports their ability to produce intelligible gestures and results in a bilingual advantage in iconic gesture production.

Keywords: Communication; adaptation; advantage; experience; parental influence; culture

Do you understand what I want to tell you?

Early sensitivity in bilinguals' iconic gesture perception and production

Communication is ambiguous and requires interpretation. To be understood and to understand others appropriately, we enrich the meaning of our communicative acts. That is, we infer our interlocutors' needs, motives, knowledge, and intentions based on shared experiences, common history, or joint attention (Tomasello, 2008; Tomasello & Carpenter, 2007). Successful communication, therefore, requires the sensitivity towards these shared experiences.

Already children display such sensitivity in communicative situations (Bohn & Köymen, 2018). For instance, infants interpreted their interaction partners' behaviour based on their shared history (Ganea & Saylor, 2007; Saylor, Ganea, & Vázquez, 2011). Similarly, pre-schoolers expected their partner to label an object in accordance with a previous agreement and protested if this label was violated by their interlocutor (Wyman, Rakoczy, & Tomasello, 2009). Furthermore, children monitor others' communicative needs (Grosse, Scott-Phillips, & Tomasello, 2013), intentions (Behne, Carpenter, & Tomasello, 2005; Schulze & Tomasello, 2015), knowledge (Liszkowski, Carpenter, & Tomasello, 2008; Tomasello & Haberl, 2003), and motives (Kuhlmeier, Wynn, & Bloom, 2003) and expect their partner to act accordingly.

Not surprisingly, children differ in the degree of this communicative sensitivity. Several studies speak to a heightened sensitivity of bilingual children to others' needs and intentions in communicative situations (Comeau, Genesee, & Mendelson, 2007; Wermelinger, Gampe, & Daum, 2017). That is, bilingual children show a greater adaptation to their interaction partner's needs when bringing their messages across and thereby ensure that they are being understood. For example, bilingual compared to monolingual pre-schoolers adjusted their description of the physical aspects of a game to a higher degree when describing it to a blind instead of a sighted person (Genesee, Tucker, & Lambert, 1975).

Similarly, bilingual but not monolingual 4- to 5-year-olds adapted their level of ostension to their interaction partner (Gampe, Wermelinger, & Daum, 2018). In this study, the children consecutively interacted with two interaction partners in a hide-and-seek game. While the first interaction partner was happy about the children's help in finding hidden objects, the second interaction partner was not. The results show that bilingual toddlers adapted the level of ostension in their helping behaviour (i.e., helped in a less obvious way) when being confronted with the second interaction partner while their monolingual peers did not (Gampe, Wermelinger, et al., 2018). Furthermore, bilingual children also show an advantage in understanding others' communicative acts. For example, bilingual infants and toddlers more often took their interaction partner's visual perspective to understand an ambiguous vocal expression (Fan, Liberman, Keysar, & Kinzler, 2016; Liberman, Woodward, Keysar, & Kinzler, 2016; Yow & Markman, 2014). Finally, bilingual pre-schoolers made better pragmatic inferences than their monolingual peers (Siegal, Iozzi, & Surian, 2009).

Bilingual children's increased sensitivity to others' needs and intentions in communicative situations may be explained by the challenges they face in their everyday interactions. First, bilinguals have smaller vocabulary sizes in each of their languages than monolinguals (Cattani et al., 2014; De Houwer, 1990; Oller, Pearson, & Cobo-Lewis, 2007; Pearson, Fernández, & Oller, 1993). Therefore, they have potentially more difficulties understanding others verbally. Similarly, they are limited when expressing themselves appropriately. Second, growing up with different languages often entails growing up with different cultures. Bilinguals need to switch between interaction partners with different culturally informed communication styles (Kandhadai, Danielson, & Werker, 2014). Therefore, a bilingual child needs to constantly monitor and track languages across different social contexts and interlocutors to ensure successful communication. Furthermore, cultures vary in how intentions are shown (Hall, 1989) and concepts are expressed (McNeill, Levy, & Pedelty, 1998) and therefore, a bilingual child will experience a greater diversity of communicative situations than a monolingual child. In sum, bilinguals face greater challenges in everyday communication than monolinguals. Mastering these challenges requires inferring and monitoring others' needs and intentions and might result in a bilingual advantage in communicative situations (Wermelinger et al., 2017; Yow & Markman, 2011, 2016).

Bilinguals' communicative advantage has also been reported for nonverbal communication. For example, bilingual toddlers were particularly sensitive to nonverbal communicative cues such as points or eye gaze (Brojde, Ahmed, & Colunga, 2012; Groba, De Houwer, Mehnert, Rossi, & Obrig, 2018). Bilinguals were better at interpreting the referent of pointing gestures to resolve ambiguous pronouns (Yow, 2015) or conflicting indications of direction (Yow & Markman, 2011) compared to their monolingual peers.

Manual gestures are one example of such nonverbal cues. Gestures may either be conventional (i.e., culturally dependent gestures that convey meaning without speech; e.g., "thumbs up" for "ok") or unconventional (i.e., spontaneously and individually produced gestures). These unconventional gestures may further be divided into deictic (e.g., pointing), metaphoric (i.e., gestures used to express abstract ideas), beat (i.e., rhythmic manual gestures during speech without meaning) or iconic gestures (i.e., gestures illustrating form or movement of referent; McNeill, 1992; McNeill et al., 1998). Developmentally, children often produce gestures before they start speaking (Leung & Rheingold, 1981; Mateo, Özçalışkan, & Hoff, 2016). Gestures help to build the vocabulary (Iverson & Goldin-Meadow, 2005; Özcalişkan, Gentner, & Goldin-Meadow, 2014), develop interactional routines (Guidetti & Nicoladis, 2008), and assist linguistic retrieval (Nicoladis, Mayberry, & Genesee, 1999). Children picked up more information (Thompson, Driscoll, & Markson, 1998) and understood teachers' instructions better when they are accompanied by gestures (Singer & Goldin-Meadow, 2005). Children's use of gestures is influenced by the language they speak (Huttunen, Pine, Thurnham, & Khan, 2013; Kendon, 2004) and partly determined by their parents gesture production (Goldin-Meadow & Saltzman, 2000; Iverson, Capirci, Volterra, &

Goldin-Meadow, 2008; Tamis-Lemonda, Song, Leavell, Kahana-Kalman, & Yoshikawa, 2012). For instance, a longitudinal study showed parental gesture use at 14 months to predict children's gesture use at 54 months (Rowe & Goldin-Meadow, 2009). Furthermore and in line with research on verbal development, previous studies on children's gesture use have shown a sex difference in early gesture processing (Bakker, Kaduk, Elsner, Juvrud, & Gredebäck, 2015) and gesture production (Acredolo & Goodwyn, 1988; Özçalişkan & Goldin-Meadow, 2010) in favour of girls.

Like any form of communication, gestures are ambiguous and need interpretation. This is especially true for iconic gestures (Tomasello, 2008). Iconic gestures resemble the form or the movement of their referent (e.g., a heart gestured with index fingers and thumbs of both hands forming a symbolic heart (form) or with a rhythmically pounding fist hovering over the chest area (movement); McNeill, 1992). Unlike other types of gestures, they often refer to something that is not physically present in the current situation. Hence, every time a child encounters such a gesture, it has to connect a hand pose or movement to the meaning that was intended by the gesturer. Similarly, every time a child gestures, it has to do it in such a way that its interlocutor interprets it appropriately. An increased sensitivity to others' needs and intentions – such as it is attributed to bilingual children – may support the understanding as well as the production of iconic gestures. However, the effect of bilingualism on children's gesture use has only been explored for the understanding of deictic gestures (Yow & Markman, 2011) or the frequency with which gestures are used during speech (Nicoladis, Pika, & Marentette, 2009). Differences in the understanding and appropriate production of iconic gestures among monolingual and bilingual children have not been studied.

In the present study, we investigated whether monolingual and bilingual children differ in their ability to understand others' iconic gestures (gesture perception) and to produce intelligible iconic gestures themselves (gesture production). Bilingual children's heightened sensitivity to their interaction partners' communicative intentions and needs might help them in perceiving and producing iconic gestures. That is, when observing others' iconic gestures, bilingual children might be better able to infer their interaction partners' communicative intention and interpret what is being gestured in the context of what is being said at the same time. Similarly, when producing iconic gestures themselves, bilingual children might adapt more to interlocutors' communicative needs and create more intelligible gestures (i.e., provide more information about the referent by using its form AND movement in the gesture).

To investigate this question, we assessed children's gesture perception and production by adapting two tasks by Botting, Riches, Gaynor, and Morgan (2010). We tested children at the age of 3 to 4 years because children start to reliably produce and understand iconic gestures only at around 3 years of age (Novack, Goldin-Meadow, & Woodward, 2015; Sekine, Sowden, & Kita, 2015; Stanfield, Williamson, & Özçalişkan, 2014). Furthermore, children might merely copy their parents' (culturally informed) use of gestures and children's gesture perception and production might be influenced by their parents gesture production (Rowe & Goldin-Meadow, 2009). Therefore, we additionally measured parental gesture frequency with a task by Feyereisen and Havard (1999).

Based on previous studies indicating a heightened sensitivity of bilingual children to their interaction partners' needs and intentions in communicative situations (e.g., Gampe et al., 2018; Yow & Markman, 2011), we hypothesized that bilingual pre-schoolers show better perception and production of iconic gestures. Specifically, we expected bilingual children to outperform their monolingual peers in a gesture perception task in which the children were asked to integrate an iconic gesture with the semantic content of a sentence. Similarly, in a gesture production task, we assumed bilinguals to provide more information about the referent of their iconic gestures than monolinguals, making their gestures more intelligible. That is, we expected bilingual children to combine form and movement to indicate the referent of their gesture more often compared to monolingual children. Since the investigation of parents' iconic gesture frequency is exploratory, we had no specific hypotheses related to the relation between gesture perception and production and parental gesture frequency.

Methods

Participants

In total, $N = 80$ 3.5 years old monolingual and bilingual pre-schoolers participated in the study (see Table 1 for demographics) together with one of their parents ($n = 4$ fathers and $n = 76$ mothers). The children and their parents were recruited in a medium-sized city in Switzerland from local birth records. Half of the children were monolingual (both parents spoke the same language: Swiss German) and half were bilingual (the parents spoke two different languages). All bilinguals spoke Swiss German and one of the following languages: English ($n = 12$), French ($n = 6$), Italian ($n = 7$), Spanish ($n = 4$), Dutch ($n = 2$), Serbian ($n = 2$), Croatian ($n = 2$), Portuguese ($n = 1$), Russian ($n = 1$), Czech ($n = 1$), Hungarian ($n = 1$), Arabic ($n = 1$). Children's language input was assessed via a parental questionnaire. Besides the waking hours of the children, the questionnaire documents the time a child spends with different custodians in a week and the languages these custodians speak. Inclusion criteria regarding bilingual children comprised a language input of at least 20 percent in each of their two major languages. Exclusion criteria included a language input of more than 10 percent in additional languages for monolingual children or in a further language for bilingual children. The majority of parents participating were native Swiss German speakers ($n = 60$).

Children's receptive and conceptual vocabulary in their mother tongue(s) was assessed via BILEX, a tool for the assessment of bilingual children's lexicons (Gampe, Kurthen, & Daum, 2018). All procedures were approved by the local research committee and performed in accordance with the ethical standards of the 1964 Helsinki declaration and its later amendments. All parents gave informed consent. Children received a small toy and a certificate after their participation.

Materials and Design

In this study, three tasks were administered: The *parental gesture frequency task* measured the frequency with which the parents of the participating children produce iconic gestures during speech. The *gesture perception task* and the *gesture production task* assessed children's perception and production of iconic gestures.

No materials were required to assess parental gesture frequency. The materials used for the children's gesture perception task consisted of 52 laminated pictures (10 x 10 cm; see Figure 1 and Appendix A1). For each trial, four pictures were glued onto a laminated sheet of paper (size A4, 21 x 29.7 cm) using a non-permanent adhesive roller and then presented on a book-rest. The children received a storybook with 14 laminated sheets (14.7 x 14.9). For each trial, the experimenter told a short sentence while replacing the last word with an iconic gesture. The children should select one of the four presented pictures to put in their storybook. Only one of the four pictures matched the semantic context as well as the gesture accompanying the sentence. The other three pictures were functioning as distractors. That is, we presented a gesture foil (only matching the gesture), a linguistic foil (only matching the semantic context) as well as an oddball foil (neither matching the semantic context nor the gesture shown). The positions of the pictures were pseudo-randomized ensuring the target picture and the three distractors were presented equally often on each of the four positions (top left, top right, bottom left, bottom right) on the sheets of paper during the experimental trials.

The materials required for the children's gesture production task included a hand puppet named "Lola" (H: 65 cm) and a wooden box (H: 29.5 cm, W: 29.5 cm, D: 3.5 cm). The box was equipped with a light sensor and painted as a treasure chest (see Figure 1). Inserting an object into the box triggered the light sensor and resulted in a quacking sound as well as LED lights flashing. Illustrations of the target objects used for the task were presented on a rotatable panel at the front of the box in such a way that the child could see only one illustration at a time. The experimenter could manipulate the rotatable panel at the back of the box. The twelve target objects used for this task included an ice cream cone, an elephant, glasses, a crocodile, a bird, a hairbrush, a monkey, a hat, a cat, an umbrella, a drum, and a book. The objects measured between 3.8 cm and 17.5 cm.

Procedure

After welcoming the child and the accompanying parent, the experimenter played with the child for 10 to 15 minutes to get acquainted while the parent filled out the language questionnaire and the consent form. Parents were present throughout the study but were asked to remain quiet and not to give any hints to their children. All children completed the trials in the gesture perception and the gesture production task in the same order.

Parental gesture frequency. To assess parental gesture frequency, we used the items of the *motor imagery* condition of a gesture production task by Feyereisen and Havard (1999). In this study, questions about manual activities (similar to the questions asked in the present study, see below) were shown to elicit iconic gestures to a greater extent than the questions asked in the other conditions (Feyereisen & Havard, 1999). To assess parental gesture frequency, the experimenter sat across from the parent accompanying the child to its lab visit while the child was encouraged to play on its own for a short time. The experimenter asked three questions to elicit gestures while answering verbally. Parents were told that they could answer in any language. The three questions were as follows: “Tell me, how would you wrap a present?”, “Tell me, how would you cook your favourite food?” and “Tell me, how would you change a car tire or how would you mend a bicycle tire?”. For the last question, the parent was allowed to choose either of the prompts. During this task, the experimenter kept her hands hidden beneath the table to make sure parents were not influenced by her gestures.

Gesture perception task. We measured children’s perception and correct understanding of iconic gestures in a task adapted from Botting, Riches, Gaynor, and Morgan (2010). Compared to Botting et al.'s (2010) *gesture comprehension task*, we administered children's gesture perception within a real-time interaction instead of videotaping the experimenter beforehand to increase the valditiy of the task. Furthermore, we reduced the number of items presented to keep the children motivated and attentive throughout the whole study. From the original task, we chose items that formed a coherent story. Spoken sentences and distractor items were changed to match the new story. Furthermore, one item was newly created (item 5; for the reliability of the new scale see Appendix A1).

The gesture perception task consisted of 13 trials, including one warm-up trial and 12 experimental trials (see Appendix A1 for sentences, gestures, and pictures of all trials). At the start of the task, the experimenter informed the child that she is going to tell a story about Anton's birthday and children were given an empty storybook. The experimenter then showed the children four pictures, and they were told that only one of the pictures was the correct one. For the warm-up trial, the experimenter said: "Watch me closely, I will show you which picture you have to put in your storybook. It was Anton's birthday. For his birthday he wanted to visit …" + *gesture for an elephant*. The experimenter then put four pictures within reach of the child. If the child chose the wrong picture, the experimenter first repeated the sentence including the gesture. If the child did not react or still chose the wrong picture, the experimenter showed the gesture separately while saying: "Watch me closely, this is an elephant …" + *gesture for an elephant*. "Which one is the elephant?". If the child did not react to the first two prompts, the experimenter pointed out the correct picture (this did not occur in our sample). During the following 12 experimental trials, children were praised when choosing any picture, regardless of their choice. If children did choose multiple pictures, they were prompted only to take the picture that fit best because there was not enough space in the storybook otherwise. After children chose one picture, they were asked to put it in their storybook they had received at the beginning of the task.

Gesture production task. To assess children's production of intelligible iconic gestures we used a task by Botting, Riches, Gaynor, and Morgan (2010). Here, the children interacted with a deaf puppet instead of an experimenter. Additionally, we used a "jingle machine" (our treasure chest) to ensure children were motivated throughout the whole task. The treasure chest lighted up and made noises every time an object was placed in it. Children should therefore be motivated to obtain the according objects. To make sure that the items used were appropriate for the cultural context and children's age, they were replaced in accordance with a short survey administered in a pre-study before the current study. In this survey, we listed all items of Botting et al.'s (2010) *gesture comprehension* and *gesture production task* that were within children's passive vocabulary (according to the age of acquisition as listed in Birchenough, Davies, & Connelly, 2017). We then asked $N = 25$ parents of 3- to 4-year-olds to indicate for which of these items their children were able to produce a gesture, understand a gesture, or both. The ten highest scoring items from this survey were used as stimuli for the current gesture production task.

Accordingly, the current gesture production task consisted of ten trials in which children were asked to indicate the objects to put into a treasure chest with the help of iconic gestures. At the beginning of the task, the experimenter presented a treasure chest and informed the children that it would light up and make sounds as soon as the correct object was thrown through an opening on top. During two familiarization trials, the child was asked to indicate the name of the object they saw at the front of the treasure chest. If they named the objects correctly, the child received the corresponding object to put them in the chest. The experimenter then told the child that she was out of objects, but that her friend Lola would provide them with more. Furthermore, the experimenter informed the child that Lola was not able to hear anything at the moment because she had been standing too close to a loudly trumpeting elephant during her visit at the zoo with Anton. To learn how to communicate with Lola, the child was asked and eventually shown in six warm-up trials how they could greet the puppet (waving hand movement), tell her “yes” (nodding) or “no” (shaking head) and show her three objects (elephant, ice cream and car) only using gestures without any speech.

With the completion of the warm-up trials, Lola was roused from her sleep. She greeted and prompted the child to show her what object was displayed on the panel. As soon as any iconic gesture was produced, Lola handed the corresponding object to the child for it to put the object in the treasure chest. The panel was rotated, and the procedure continued until all ten objects were shown to the child. If a child tried to name an object instead of using gestures, Lola asked the child to show her with their hands, mentioning that she was not able to hear what they were saying. After 15 seconds of no reaction or no iconic gesture shown, Lola asked the child: “What does the object look like? What can you do with it?” If the child did not show an iconic gesture for another 15 seconds, the panel was rotated, and the next trial began.

Coding. The study was videotaped and parents', as well as children's behaviour, was coded from the video. All research assistants coding children’s and parents’ behaviour were blind to the hypotheses. For the assessment of parental gesture frequency, a research assistant assessed the number of iconic gestures shown by the parent (divided into either iconic form or iconic movement gestures; according to McNeill, Levy, & Pedelty, 1998). A second research assistant recoded 25% of the participating parents (Cohen's $\kappa > 0.82$). For every question, only the first minute of the parental answer was considered and was split into five-second segments. In accordance with the original task (Feyereisen & Havard, 1999), parental gesture frequency was calculated by dividing the number of segments in which the parents showed an iconic gesture by the total number of segments. This was done because start and end points of iconic gestures shown within the task were often not discrete enough to reliably code their raw frequency. Because of the same reason, we did not analyse the form or intelligibility of parents’ iconic gestures.

For the children's gesture perception task, a research assistant coded children's behaviour in choosing one of the four pictures. A second research assistant recoded 25% of the participating children (Cohen's κ = .999). A gesture perception score was calculated by awarding points according to the pictures that were chosen by the children: target picture (matching both gesture and semantic context) = 2 points, gesture foil = 1 point, linguistic foil = 0 points, oddball foil = 0 points.

In the gesture production task, a research assistant coded children's gestural responses and a second research assistant recoded 25% of the participating children (Cohen's κ = 0.74 - 0.85). For every object, it was assessed whether the child showed an iconic gesture and if that was the case, what kind of iconic gesture (i.e., form or movement) the child produced. We considered gestures involving the form and the movement of the corresponding object to be more intelligible than gestures that only involved the form or only the movement of the object. Hence, to evaluate the intelligibility of children's iconic gestures within a gesture production score, we awarded points to the children's behaviour as following: iconic gesture showing form and movement of the object = 2 points, iconic gesture showing only form or only movement = 1 point, no or other gesture = 0 points. For example, gesturing a crocodile by forming a mouth-like shape with both hands (form) while opening and closing the hands (movement) was awarded with two points.

Results

All data used for the analyses are openly available (https://osf.io/83eqk/). To assess whether monolingual and bilingual children differed in their iconic gesture perception or production, we ran two cumulative link models for trial-wise ordinal data (Christensen, 2011). Since girls show increased gesture processing and production (Bakker, Kaduk, Elsner, Juvrud, & Gredebäck, 2015; Özçalişkan & Goldin-Meadow, 2010), sex was entered as a factor into the models. Hence, we predicted children's gesture perception score and gesture production score with their sex and their language status (monolingual/bilingual).

Parental gesture use influences children's gesture use (Rowe & Goldin-Meadow, 2009). Therefore, we analysed whether monolinguals' and bilinguals' parents differed in their gesture frequency using a linear regression model of children's language status on parental gesture frequency. To further explore the influence of parental gesture use on children's iconic gesture perception and production, we ran two cumulative link models predicting children's gesture perception and production score with parental gesture frequency.

Children's iconic gesture perception

The model on the gesture perception score revealed a main effect of sex, *Estimate* = 0.700, *SE* = 0.283, $p = .013$, with girls having a higher gesture perception score than boys. While no main effect of language status was found, *Estimate* = 0.450, *SE* = 0.282, $p = .111$, an interaction between language status and sex emerged, *Estimate* = -0.880, *SE* = 0.398, $p = .027$. However, using Tukey's tests, post-hoc comparisons revealed no significant contrasts. Descriptively, monolingual boys showed a slightly smaller gesture perception score than monolingual girls, $p = .064$.

Children's iconic gesture production

For the following reasons, we excluded $n = 6$ participants from the analysis of the gesture production task: experimenter error ($n = 4$; 3/1 boys/ girls, 2/2 bilingual/monolingual), children were scared of the puppet ($n = 2$; 1/1 boy/girl, 2/0 bilingual/monolingual).

The model on the gesture production score (Figure 2) revealed a main effect of sex, *Estimate* = 0.518, *SE* < .001, $p < .001$, a main effect of language status, *Estimate* = 1.011, *SE* = 0.457, $p = .027$, but no interaction between sex and language, *Estimate* = -0.962, *SE* = 0.628, $p = .125$. Girls produced more intelligible gestures than boys, and bilinguals produced more intelligible gestures than monolinguals.

To further investigate whether the effect of language status was influenced by a specific second language of bilinguals, we predicted children's gesture production score with their (second) language using cumulative link models for trial-wise ordinal data. The model

(Figure 3) revealed no effect of language, $Estimate_{English}$ = 0.065, *SE* = .650, *p* = .920 (*n* = 11), $Estimate_{French}$ = 0.583, *SE* = .829, *p* = .481 (*n* = 6), $Estimate_{Italian}$ = 0.656, *SE* = .884, *p* = .458 (*n* = 5), $Estimate_{Spanish}$ = 0.556, *SE* = .986, *p* = .573 (*n* = 4) and $Estimate_{Other}$ = 0.849, *SE* = .674, *p* = .208 (Dutch *n* = 2, Portuguese *n* = 1, Russian *n* = 1, Serbian *n* = 2, Czech *n* = 1, Croatian *n* = 2, Arabic *n* = 1). Children speaking different (second) languages did not systematically differ in their iconic gesture production score.

Parents' iconic gesture frequency

Children's language status significantly predicted parental gesture frequency, β = 0.127, *SE* = 0.062, *p* = .043. Parents of bilingual pre-schoolers produced more iconic gestures than parents of monolinguals.

To assess whether this effect is influenced by parents' own language background, we ran two Wilcoxon signed rank tests exploring the iconic gesture frequency of non-Swiss German speaking and Swiss German speaking parents. First, we analysed whether parents speaking a non-Swiss German language (*n* = 20) differed from parents speaking Swiss German (*n* = 20) in their gesture frequency within the bilingual sample only. There was a significant difference, *W* = 96.5, *p* = .045, indicating that non-Swiss German speaking parents (*M* = 0.68, *SD* = 0.19) gestured more than Swiss German speaking parents (*M* = 0.51, *SD* = 0.24). A second Wilcoxon signed rank test analysed whether there was a difference in the gesture frequency of Swiss German speaking parents of bilinguals (*n* = 20) and Swiss German speaking parents of monolinguals (*n* = 40). No significant difference emerged, *W* = 421, *p* = .398. Swiss German speaking parents of bilinguals did not differ from Swiss German speaking parents of monolinguals (*M* = 0.46, *SD* = 0.29) in their iconic gesture frequency. Taken together, the language spoken by the parents (non-Swiss German vs. Swiss German) influenced their iconic gesture frequency with non-Swiss German speaking parents gesturing more than Swiss German speaking parents.

Parents' iconic gesture frequency and children's iconic gesture perception and production

Parents' iconic gesture frequency showed no significant relation with children's iconic gesture perception, *Estimate* = 0.237, *SE* = 0.412, $p = .565$, when controlling for children's language status, *Estimate* = 0.149, *SE* = 0.249, $p = .550$, their sex, *Estimate* = 0.263, *SE* = 0.210, $p = .209$, as well as the language of the parent participating in the study (Swiss German vs. non-Swiss German), *Estimate* = -0.085, *SE* = 0.308, $p = .782$.

Similarly, parents' iconic gesture frequency did not predict children's iconic gesture production, *Estimate* = -0.882, *SE* = 0.906, $p = .330$, when controlling for children's language status, *Estimate* = 0.625, *SE* = 0.538, $p = .245$, their sex, *Estimate* = -0.191, *SE* = 0.457, $p = .676$, as well as the language of the parent participating in the study (Swiss German vs. non-Swiss German), *Estimate* = 0.882, *SE* = 0.691, $p = .202$. Taken together, parental iconic gesture frequency was not associated with children's iconic gesture perception and production.

Discussion

This study investigated whether monolingual and bilingual pre-schoolers differ in their ability to understand others' iconic gestures and produce intelligible iconic gestures themselves. Based on previous studies demonstrating bilingual children's increased sensitivity to others' needs and intentions in communicative situations (Gampe, Wermelinger, et al., 2018; Wermelinger et al., 2017), we predicted a bilingual advantage in iconic gesture perception as well as production. Results indicate that growing up with two languages had no effect on children's understanding of others' iconic gestures. In contrast, bilingual children were shown to produce more intelligible iconic gestures than their monolingual peers. Replicating previous findings, the girls in the current study showed enhanced understanding of others' gestures and produced more intelligible iconic gestures than the boys (Bakker et al., 2015; Özçalişkan & Goldin-Meadow, 2010).

In addition to our main rationale, we also explored parental gesture frequency. The results show that parents of bilingual children gestured more than parents of monolingual children. However, parents' iconic gesture frequency was not related to children's iconic gesture perception and production.

Children's iconic gesture perception

Previous literature on the differences between monolingual and bilingual children's communicative abilities has focused on verbal communication (Genesee et al., 1975; Siegal et al., 2009) and nonverbal signals such as gaze and pointing gestures (Yow, 2015; Yow & Markman, 2011). We add to this literature by exploring monolingual and bilingual children's ability using a more complex form of nonverbal communication, namely gestures (McNeill, 1992). Iconic gestures often have referents that are not physically present and require some form of interpretation based on the given context (McNeill, 1992; Tomasello, 2008). In the gesture perception task, this context was largely determined by the sentence that accompanied the iconic gesture. That is, we asked children to choose a picture that fits the semantic content of what was being said as well as the iconic gesture shown. Contrary to our hypothesis, we found no difference between monolingual and bilingual children in this task. Hence, even though bilingual children showed a heightened sensitivity in communicative situations in previous studies (e.g., Fan, Liberman, Keysar, & Kinzler, 2016; Liberman, Woodward, Keysar, & Kinzler, 2016), this might not have helped them to interpret iconic gestures in the context of speech in the current study.

Another explanation might be that our task was not demanding enough to differentiate between the two language groups. That is, in previous work, bilingual children were shown to outperform their monolingual peers mainly in more challenging communicative situations. For instance, in the study by Yow and Markman (2011) 3- and 4-year-olds were asked to indicate the location of a toy in one of two boxes. The experimenter gave nonverbal cues; some of them indicated the location of the toy (i.e., pointing gesture, eye gaze) and some of them did not (i.e., proximity). Only in the most demanding condition, where two nonverbal cues (i.e., gaze to correct box and proximity to empty box) contradicted each other, bilingual children outperformed monolinguals. Therefore, although differences between monolingual and bilingual children in gesture perception might be present, they might only occur in more difficult tasks (e.g., a task with more complex iconic gestures or sentences) than the standardized task suitable for 3- to 4-year-olds (Botting et al., 2010) we used. Future research will have to explore whether differences in iconic gesture perception between monolingual and bilingual children can be detected in more challenging tasks.

Children's iconic gesture production

When we produce iconic gestures, we want our interaction partner to derive their meaning as it was intended. An interlocutor is more likely to interpret the gesture appropriately, when more information is provided (i.e., by using form and movement of the referent). In our gesture production task, bilingual pre-schoolers more often included both the form and the movement of the desired object than monolinguals. We assume that this advantage in gesture production resulted from bilinguals' increased experience with a greater diversity and probably more challenging communicative situations. Specifically, because of bilingual children's smaller vocabulary in each of their languages (Oller et al., 2007) as well as culturally informed differences in communication styles (Kandhadai et al., 2014), bilinguals may have greater difficulties in communicating clearly and comprehensibly when using speech only. To still deliver messages in an intelligible way, non-verbal cues such as (iconic) gestures might be especially suitable in a multilingual environment because they are less language-specific and therefore more likely to be understood by any interaction partner. Furthermore, the greater variety in communicative situations contributes to a heightened ability of bilingual children to infer their interaction partners' needs and intentions from more variable cues (Gampe, Wermelinger, et al., 2018; Genesee et al., 1975; Wermelinger et al., 2017). Bilinguals' increased communicative sensitivity may have helped them to adapt to the communicative situation and produce gestures that were more likely to be understood by their interlocutor.

Findings on another group of children, who are also likely to experience challenging communication, support this assumption. Previous studies on deaf children, who do not receive input in sign language (homesigners), show that these children nevertheless develop a structured sign system, which gives them the chance to communicate to hearing interaction partners (Goldin-Meadow, McNeill, & Singleton, 1996; Goldin-Meadow, Mylander, & Franklin, 2007). Their sign use seems to be independent of the input they receive (Goldin-Meadow, Mylander, de Villiers, & Bates, 1984; Özçalışkan & Goldin-Meadow, 2005). Instead, it is assumed that homesigners create signs out of the need to communicate. To some degree, a similar mechanism might be involved in the (iconic) gesture development of hearing children. That is, children might create some (iconic) gestures spontaneously as a reaction to the affordances of the situation or the interaction partner. These affordances are likely to differ between monolingual and bilingual children, with bilingual children experiencing higher affordances to communicate non-verbally.

Alternatively, the increased intelligibility of bilingual children's iconic gestures may have resulted from differences in culturally informed gesture use (Goldin-Meadow & Saltzman, 2000; Huttunen et al., 2013; Iverson et al., 2008; Kendon, 1994). Form, variety and frequency of iconic gestures used by children differ between languages or cultures (Iverson et al., 2008). For example, in a study with 2-, 3-, and 5-year-old monolinguals, British children produced more iconic gestures while naming objects compared to Finnish children (Huttunen et al., 2013). Furthermore, monolingual Italian children are shown to produce more and also more different iconic gestures than English speaking monolinguals during storytelling (Iverson et al., 2008; Marentette, Pettenati, & Volterra, 2016). In contrast, other studies do not report a difference in iconic gesture frequency between French, English, and Spanish speaking children (Nicoladis, Marentette, & Navarro, 2016; Nicoladis et al., 2009).

Nevertheless, bilingual children's more adaptive use of iconic gestures in the current study might be a function of their relatively "gesture rich" second language/culture compared to the Swiss German of the monolinguals and not an effect of bilingualism per se. While we cannot exclude this possibility with the current data, we would like to highlight two points that speak to the difference in children's iconic gestures being an effect of bilingualism. First, when looking at children's iconic gesture production score across languages, no language spoken by the bilinguals was significantly associated with children's iconic gesture production (Figure 3). Descriptively, for example Italian children alone did not produce more intelligible iconic gestures than French children. Second, research with adults shows that bilinguals have different "gesture repertories" and use gestures in accordance with the language they speak in the very moment (Azar, Backus, & Özyürek, 2019; Cavicchio & Kita, 2013). Since the context of the current study was Swiss German, we would expect bilingual children to be more likely to use their Swiss German repertory of iconic gestures and not the one of their second language. Differences in the relative "gesture richness" of their second language is not likely to influence their gesture use in the gesture production task. Instead, we suggest that bilingualism has an effect on children's gesture use independent on the language spoken at the moment and that the difference in children's iconic gesture production in the current study resulted from bilinguals' increased experience with more challenging communicative situations. However, to support this interpretation future studies will have to compare bilinguals to different reference languages (e.g., monolingual German and Italian children compared to bilingual German-Italian children).

Parents' iconic gesture frequency and children's iconic gesture production

Our findings on parental iconic gesture frequency show that parents of bilinguals use more iconic gestures during speech than parents of monolinguals. As mentioned above, previous research indicates differences between languages or cultures in the variety and the frequency of gestures used in interactions (Goldin-Meadow & Saltzman, 2000; Huttunen et al., 2013; Iverson et al., 2008; Kendon, 1994). In line with this work, the heightened iconic gesture frequency of bilingual children's parents in the current study might be attributed to cross-linguistic differences in gesture use (Nicoladis, 2007). Specifically, an increased number of gesture-rich countries in our bilingual sample might have resulted in the observed difference between parents of bilinguals and parents of monolingual children. Since the parents communicated in their native language, they are likely to have used the according gesture repertory (Azar et al., 2019; Cavicchio & Kita, 2013). This assumption finds support in the comparison of the gesture frequency of Swiss German speaking and non-Swiss German speaking parents. Within our bilingual sample, parents speaking a non-Swiss German language gestured more than Swiss German speaking parents. Furthermore, Swiss German speaking parents of bilinguals did not differ from parents of monolinguals in their gesture frequency. These analyses speak to the assumption that bilingual children's parents' heightened iconic gesture frequency was a result of culturally informed gesture use. Future studies will have to explore the gesture frequency of both parents and assess the relative gesture-richness of the parents' cultural background to investigate this hypothesis further.

Regardless of its reason, bilingual children's parents' greater gesture frequency might have contributed to their children's iconic gesture production. Specifically, bilingual pre-schoolers' increased exposure to iconic gestures by their non-Swiss German speaking parent might support and elevate the intelligibility of their iconic gestures. Previous work indicates that parental gesture use is one possible route through which children acquire form and frequency of their gesturing (Rowe & Goldin-Meadow, 2009). For instance, children's ability to understand and produce iconic gestures is shown to increase around their second birthday (Namy, Campbell, & Tomasello, 2004; Özcalişkan et al., 2014), at about the same time when also their parents increase their use of iconic gestures (Özçalişkan & Goldin-Meadow, 2011). In contrast, in our sample, parents' iconic gesture frequency did not predict children's iconic gesture production. Bilinguals' higher gesture production score may therefore not be primarily attributed to their parents' greater production of gestures but the results rather speak for an effect of the particular requirements of communication and the resulting heightened sensitivity towards communicative affordances bilinguals face. Studies with homesigners indicate that children's production of gestures is independent of parental input (Goldin-Meadow et al., 1984; Özçalışkan & Goldin-Meadow, 2005).

However, we assessed iconic gesture frequency while parents were interacting with an adult. This frequency might differ from parents' gesture use with their children. However, previous studies have shown, that parents' cultural background influences how they use gestures with their children (Goldin-Meadow & Saltzman, 2000). Hence, it is likely that an Italian mother will gesture more than an American mother irrespective of her interaction partner (adult/child) and that our measure of parental gesture frequency has approximated parents' gesture use with their children. Future studies may further explore the interplay between parents' and children's gestures in a multilingual context, the relative contributions of environmental factors and children's individual development, as well as the mechanisms of gesture development.

Conclusion

Successful communication requires sensitivity for shared experiences and the interaction partner's needs, motives, knowledge, and intentions. Previous work indicates a bilingual advantage in this domain. Our findings support and expand this work by showing differences in monolingual and bilingual children in a more complex form of nonverbal communication that are iconic gestures. Specifically, bilinguals outperformed their monolingual peers in producing intelligible gestures and increasing the chances of being understood appropriately.

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Tables & Figures

Table 1

Participant Characteristics

	Monolinguals *M*(*SD*)	Bilinguals *M*(*SD*)	Group Comparison
Age in days	1350(84)	1377(83)	$W = 973$, $p = .096$
Parental education	4.8(1.7)	4.6(1.7)	$W = 760$, $p = .679$
% Input Swiss German	99(2.1)	54(17.9)	$W = 0$, $p < .001$
Receptive vocabulary in Swiss German	36.0(5.3)	33.0(5.4)	$W = 881.5$, $p = .009$
Conceptual vocabulary	36.0(5.3)	39.5(5.4)	$W = 906$, $p = .004$
Girls / Boys	20 / 20	21 / 19	$X^2 = 0$, $p = 1$

Notes. Parents' highest education score ranges from 1 (none) to 6 (university).

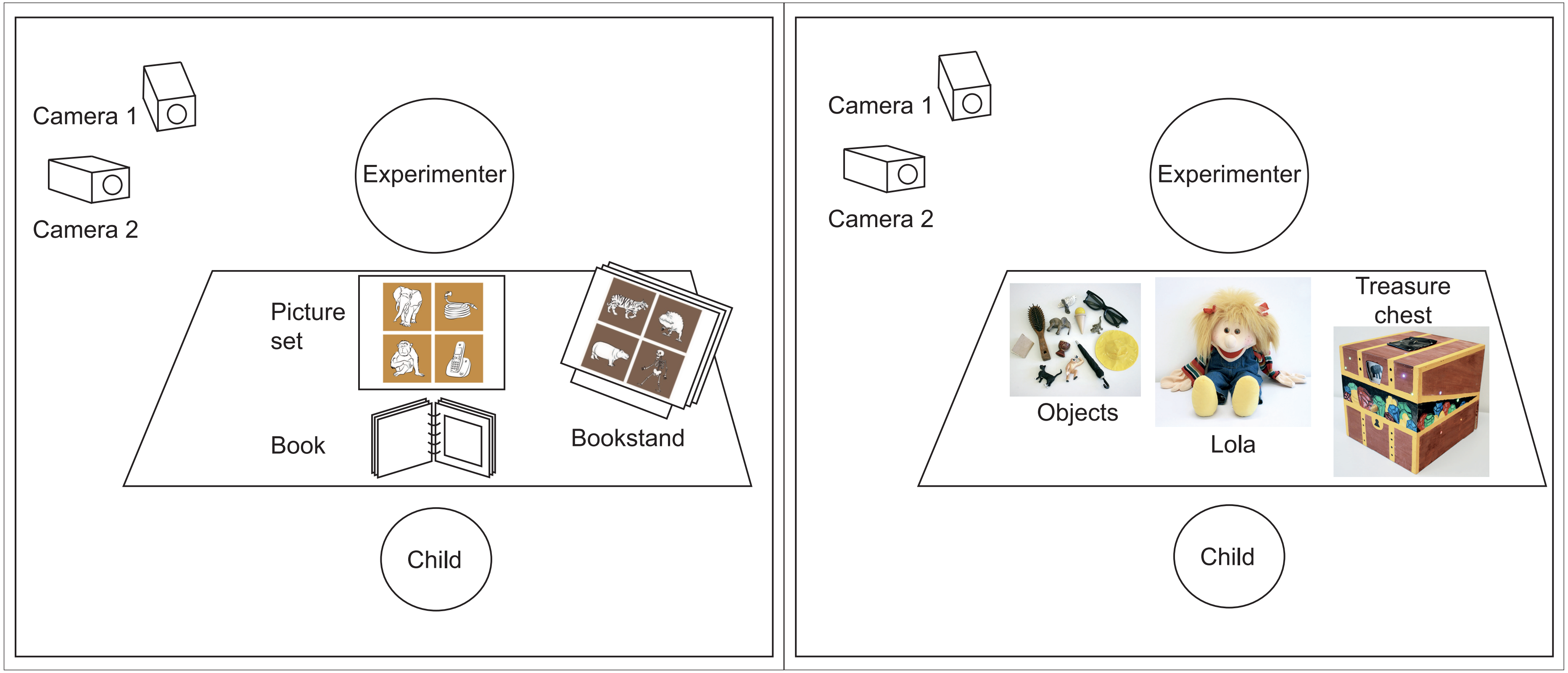


Figure 1. Schematic illustration of experimental setting for gesture perception task (left) and gesture production task (right).

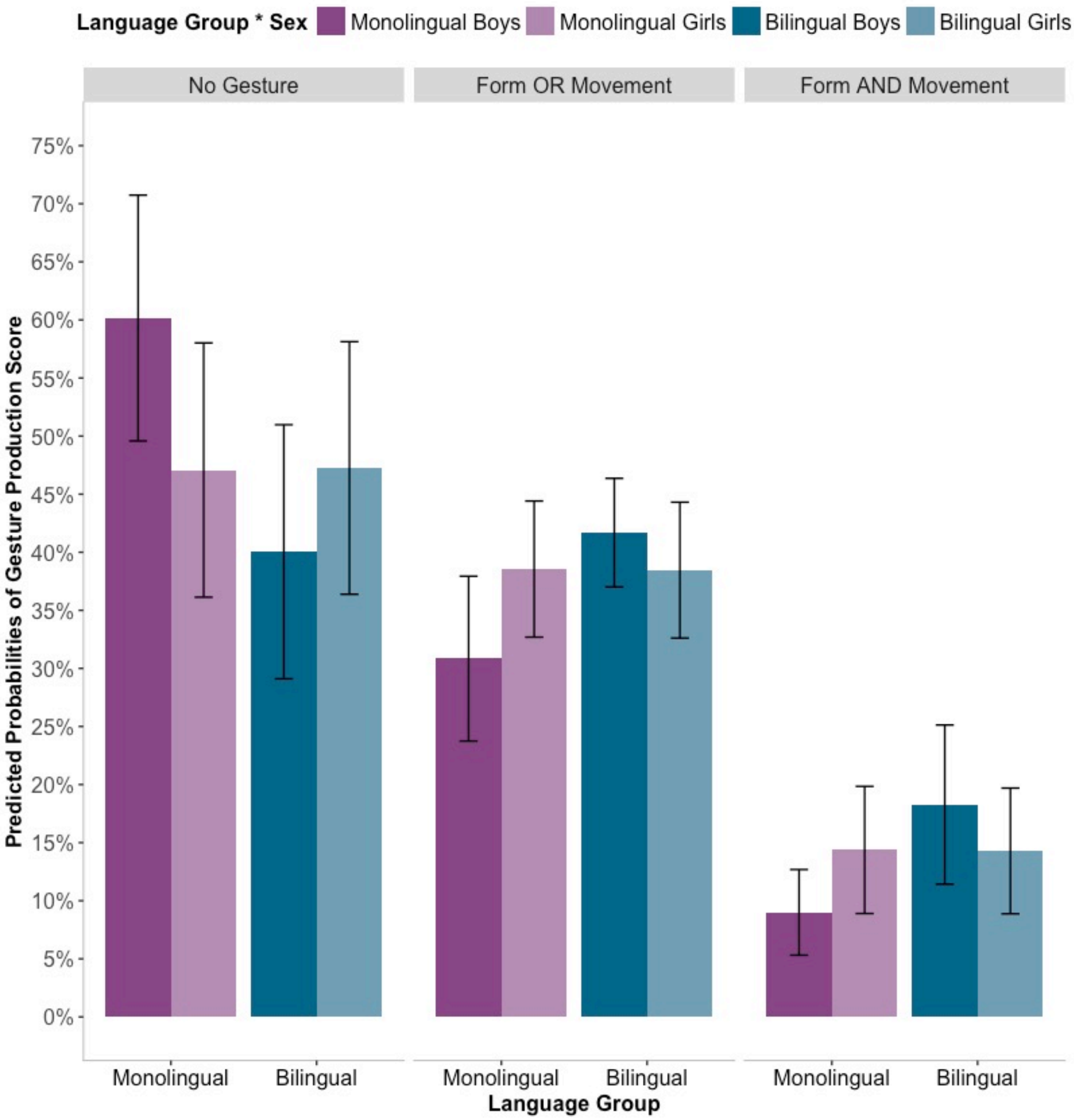


Figure 2. Predicted probabilities of monolinguals' (purple) and bilinguals' (blue) gesture production score per possible behaviour (i.e., no iconic gesture; form or movement of referent; form and movement of referent in iconic gesture).

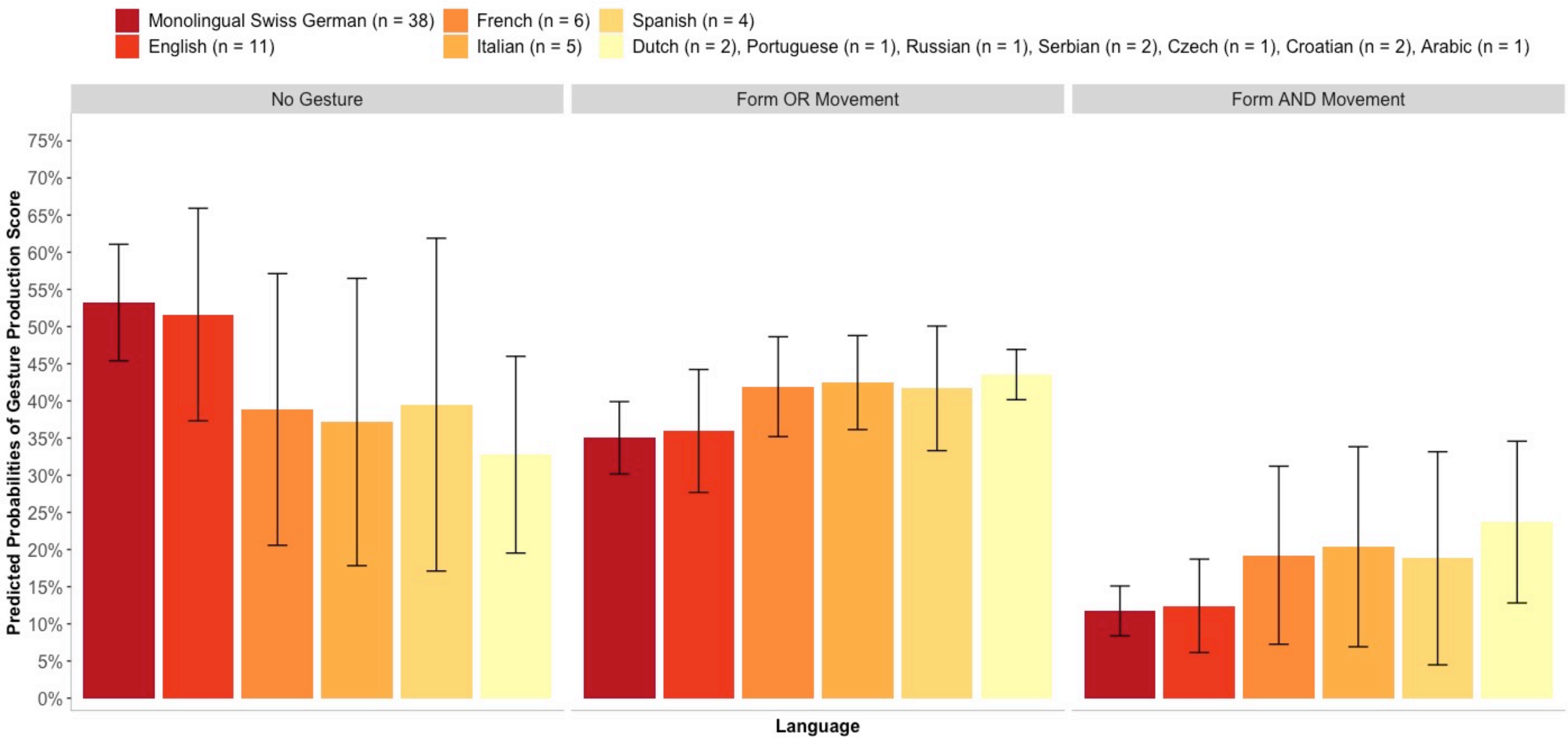
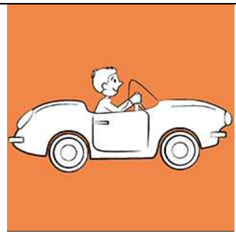
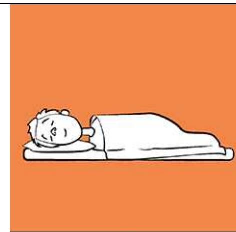
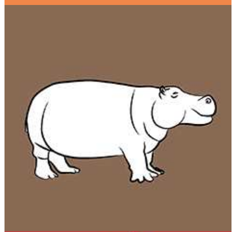
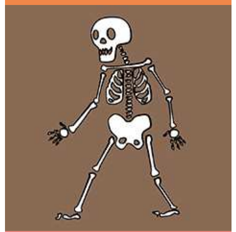
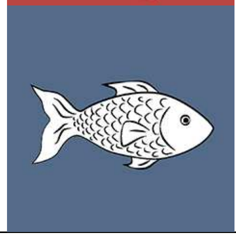
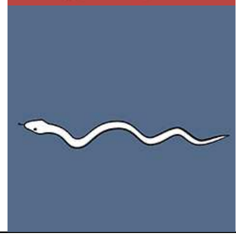
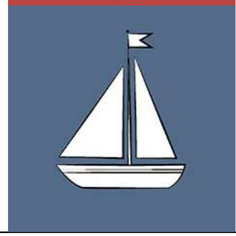
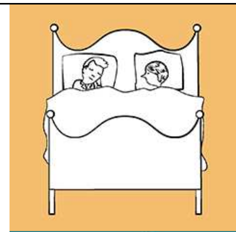
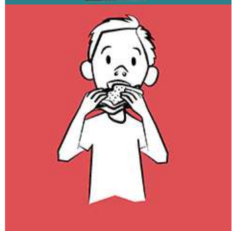
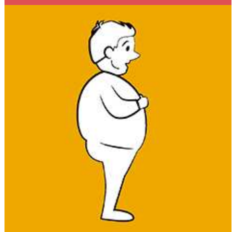
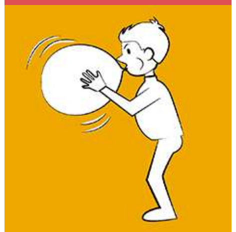
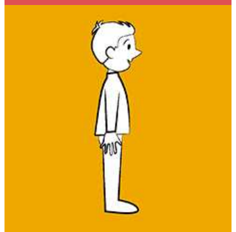


Figure 3. Predicted probabilities of children's gesture production score across (second) languages per possible behaviour (i.e., no iconic gesture; form or movement of referent; form and movement of referent in iconic gesture).

Appendix A

Trial	Sentence	Gesture	A) Target picture	B) Gesture foil	C) Linguistic foil	D) Oddball foil	r	r^{final}
1	Anton drives to the zoo with … (car)	Make stiring wheel action with both hands.					0.25	0.22
2	There are many animals in the zoo and Anton sees a … (tiger)	Snarl & make claws with hands.					-0.00	-
3	The tiger roars loudly and Anton … (is scared)	Open mouth & look scared. Open hands & hold to sides of face.					0.42	0.45
4	In the water there are many colorful … (fish)	Use flat hand with thumb up to make a sinuous movement.					0.43	0.37

Trial	Sentence	Gesture	A) Target picture	B) Gesture foil	C) Linguistic foil	D) Oddball foil	r	r^{final}
5	After the visit to the zoo all sit together around a table and … (eat)	Make grabbing action & lift the hand to the mouth.					0.21	-
6	Anton tastes the soup and it needs more … (salt)	Clasp caster, tip upsidedown and shake.					0.19	0.37
7	As the birthday cake arrives all guests … (sing)	Open mouth in singing gesture. Hold hands in an operatic manner.					0.25	0.31
8	Anton has eaten so much cake, now he feels very … (fat)	Puff out cheeks & use hands to show the size of one's stomach.					0.44	0.48
9	Together with the cake, Anton's parents have some … (tea)	Put thumb and index finger around a small handle & raise to mouth.					0.17	-

Trial	Sentence	Gesture	A) Target picture	B) Gesture foil	C) Linguistic foil	D) Oddball foil	*r*	r^{final}
10	After they cleaned the table, Anton's mum … (does the washing up)	Put one hand flat & make a scrubbing motion with the other.					0.48	0.55
11	Anton's dad makes a joke. It is very … (funny)	Laugh & hold hands to stomach.					0.48	0.54
12	All want to dance and Anton's mum plays … (the piano).	Piano playing movement.					0.42	0.29

Figure A1. Stimuli, original item correlation (*r*; corrected for item overlap and scale reliability) as well as the final item correlation (r^{final}; after exclusion of trials 2, 5 and 9) of gesture perception task. The overall Cronbach's alpha of the final scale was $\alpha = 0.58$. The warm-up trial was excluded because children's responses showed no variance, Trial 2 was excluded because of its negative correlation with the other items and Trial 5 and Trial 9 were excluded because they correlated little with the other items.